

## **Appendix A – Final Specifications and Drawings**

## 1.6 SITE CONDITIONS

- A. The water production wells shall be drilled at the Volta Wildlife Refuge, Merced County, California. The approximate locations of the proposed production wells are shown on Drawing G3.
- B. The production wells will be constructed in water-bearing units below the regional Corcoran Clay. Preliminary target depths are based on a test boring drilled to 660 feet below ground surface in 2005 at well location #1. The lithologic log describing site geology is attached.
  - 1. The above general description of the hydrogeologic conditions is provided to familiarize CONTRACTOR with conditions in the area. This information shall not be construed as indicating these conditions will be encountered in the Work. CONTRACTOR shall be responsible for providing adequate equipment and methods for properly drilling the well under any subsurface condition that could reasonably be expected.

## PART 2 PRODUCTS

### 2.1 CASING

- A. All well casings shall be new. All production well casings shall be constructed of either 1/4-inch or 5/16-inch thick steel plate and shall be manufactured in conformance with ASTM A 139, Grade B with less than 0.20 percent copper by ladle analysis.
- B. The production well casings shall be factory-assembled, 18-inch-inside-diameter, and not less than 20-foot sections, unless approved by COR, and shall contain one longitudinal seam parallel to the casing axis, or one spiral seam, and not more than one circumferential seam in 10 feet. CONTRACTOR shall submit certified test reports to the COR to indicate compliance with the required properties of the casing.
- C. Monitoring well casings shall be constructed of 2.5-inch internal diameter, Schedule 80 polyvinyl chloride (PVC).

### 2.2 SCREEN

- A. Production well screens shall be new and constructed of either 1/4-inch or 5/16-inch-thick steel plate. Screens shall be manufactured in conformance with ASTM A 139, Grade B with less than 0.20 percent copper by ladle analysis. Screens shall be constructed with an inside diameter measuring 18-inches and an aperture size identified by the COR after review of the sieve analyses provided by CONTRACTOR as described in Paragraph 3.1.B.2, below. Screens shall be full-flow louver or wire-wrap.

- B. Monitoring well screens shall be new and constructed of 0.040-inch slotted, 2.5-inch internal diameter, Schedule 80 PVC.

### 2.3 CENTRALIZERS

- A. Well casings and screens shall be fitted with approved centering guides or brackets, installed at approximately 40-foot intervals above the screen, or points as directed by the COR, but in no case more than at 60-foot intervals. These guides shall be oriented in such a manner as to facilitate the installation and removal of tremie pipes required for grouting operations and filter packing in the annulus.

### 2.4 FILTER PACK MATERIAL

- A. The filter pack material shall be at least 95 percent silica in composition. It shall be hard, well-rounded, graded, water-worn material washed clean of silt, dirt, and foreign matter (crushed gravel, angular particles, or other non-specified material will not be accepted). Filter pack material shall be subject to the approval of the OGR. Filter pack specification shall be identified by the COR after review of the sieve analyses provided by CONTRACTOR as described in Paragraph 3.1.B.2., below. CONTRACTOR shall have certified testing laboratory perform a sieve analysis to verify conformance with the specified gradation and material. Failure to meet the specified gradation or material requirements will result in rejection of the filter pack material provided by CONTRACTOR. The filter pack material, if stockpiled at the well site, shall be kept free of all foreign matter.

### 2.5 CONCRETE GROUT

- A. Concrete grout shall consist of a mixture of Portland cement conforming to the requirements of ASTM C 150, Type II, sand, coarse aggregate (maximum size - 1/4-inch) and water in the proportion of at least five bags of cement per cubic yard and not more than six gallons of clean water per bag of cement (one cubic foot or 94 pounds). Curing additives, such as calcium chloride, shall not exceed two percent of the total weight, and bentonite as an additive shall not exceed five pounds per bag of cement.

### 2.6 CEMENT GROUT

- A. Neat Cement Grout: A mixture of Portland Cement (ASTM C 150) and not more than six gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The neat cement grout weight shall be measured prior to installation as an indicator of the cement-water mix ratio. The cement grout slurry shall not exceed 15.6 lb/gal (117 lb/cf).
- B. Neat Cement Grout with Bentonite: The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C 494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry, shall be approved by the OGR prior to placement. The neat cement grout

weight shall be measured prior to installation as an indicator of the cement-water mix ratio. The cement grout slurry shall not exceed 15.6 lb/gal (117 lb/cf).

- C. Pozzolanic Cement Grout. The use of pozzolanic (fly ash) material as an additive shall comply with ASTM C 618, and shall not exceed 50 percent by volume of the cement.

## 2.7 FORMATION STABILIZER

- A. Formation stabilizer shall consist of a mixture of bentonite and sand, in equal proportions.

## PART 3 EXECUTION

### 3.1 PILOT HOLE

- A. Drilling Method:
  - 1. CONTRACTOR shall arrange for subsurface utility clearance within 10 feet of the pilot hole and hand-auger to a depth of 5 feet.
  - 2. CONTRACTOR shall be responsible for clearing and leveling the area surrounding the pilot hole to provide a work space of sufficient size for equipment and supplies.
  - 3. CONTRACTOR may elect to drill or auger the surface casing borehole and install the casing as described under Paragraph 3.2.A.5., below. CONTRACTOR shall do this at his own risk since the CO may choose to abandon the pilot hole instead of completing the water production well.
  - 4. The mud rotary drilling method shall be used by CONTRACTOR for the drilling of the pilot hole.
  - 5. The pilot holes shall be drilled to a 900-foot depth. Upon completion of drilling of the pilot holes, geophysical logging will be conducted.
  - 6. The diameter of the pilot holes shall be sufficient to accommodate conventional geophysical logging tools, as specified in Paragraph 3.1.D.3., below.
  - 7. Water alone shall be employed as drilling fluid. Should lost circulation or other drilling conditions require the addition of bentonite, lost circulation materials, or other such materials, the addition of these materials shall be made only upon approval of the OGR. Procedures shall be adapted to ensure the removal of these additives during development. CO and OGR will coordinate with GOVERNMENT for access to a source of potable

water. CONTRACTOR shall provide clean water tank and transport water to Site, as applicable.

8. In the event that lost circulation conditions are encountered during the reverse circulation rotary drilling process, immediate remedial action shall be taken by CONTRACTOR to restore circulation of the drilling fluid by conventional techniques. Cementing, except under extraordinary conditions, shall not be employed below the projected static water level. Only materials acceptable in typical water production well drilling shall be used to control loss of circulation. These materials shall consist of wood fiber, nut shells, mica, clays, gels, or other suitable materials and shall be approved by the OGR prior to use.
9. CONTRACTOR shall be allowed to discharge cuttings to the ground surface. CONTRACTOR shall spread out the cuttings to avoid mounding, and shall grade cuttings after each drilling phase is completed. The complete drilling of the pilot hole shall be done by CONTRACTOR to fulfill the Contract requirements.

B. Geological Sampling during Pilot Hole Drilling:

1. Samples of drilled material shall be taken through the target production zones (approximately 450 feet below ground surface to 900 feet below ground surface) using wire-line coring, split-spoon sampling, or equivalent method. Samples will be collected for purposes of generating a lithologic profile of the subsurface soils and collection of representative samples for grain size analyses. Loose soil samples from the shaker are not acceptable for grain size analyses. CONTRACTOR shall take steps to ensure the accuracy of depth levels for sample collection to ensure the soil samples are representative of the depth through which drilling is proceeding. CONTRACTOR shall be responsible for the safe storage of formation samples until such time as they are accepted by OGR.
2. CONTRACTOR shall submit a minimum of five samples of drill cuttings, selected by the OGR, to a casing manufacturer or certified geophysical testing laboratory approved by CO for sieve analysis by ASTM Method 422 to determine grain size distribution. Results of the sieve analyses shall be made available to the COR within 24 hours of completion.

C. Well Log:

1. An accurate written log shall be maintained at all times by CONTRACTOR. CONTRACTOR shall record the type, character, and depth of materials encountered, thickness of strata, water table depth, and any additional information that may be helpful in interpreting the drilling log. In addition, CONTRACTOR shall maintain a Drilling Penetration Rate Log at all times during drilling operations. The Drilling Penetration

Rate Log shall include depth of penetration per time interval using a geolograph, or equal instrumentation, and shall also include documentation of periods of inactivity, fluid circulation, and other pertinent details as determined by the OGR. All measurements for depths shall be referenced to existing ground surface at the water production well site. On completion of the pilot hole, five copies of the driller's formation log and the Drilling Penetration Rate Log shall be furnished to the COR.

D. Geophysical Logging:

1. After reaching total depth of the pilot hole, CONTRACTOR shall continue circulation for sufficient time to remove the cuttings from the hole. If the geophysical logging tools cannot be lowered to the bottom of the pilot hole, CONTRACTOR shall run the drilling tools to the bottom and circulate the hole clean at CONTRACTOR's expense.
2. Geophysical logging will be conducted at the expense of CONTRACTOR. Geophysical logs shall be made available to the COR in electronic format as soon as possible and no more than 24 hours after completion.
3. The following geophysical logs shall be obtained:
  - a. Spontaneous Potential and Resistivity Log (Electric log), including point, 16- and 64-inch, and 6-foot lateral.
  - b. Gamma Ray and Gamma-Neutron Log.
  - c. Temperature Log.
  - d. Acoustic Log (3-D velocity with 2 spacings).
  - e. Electrical Conductivity Log.

E. Evaluation:

1. CONTRACTOR shall prepare a preliminary well design and submit the design to COR for approval within 48-hours of receipt of the final sieve analyses and geophysical log. The CO will require a 5-day period, commencing with receipt of the final sieve analyses and geophysical log in order to review and evaluate the findings of the pilot hole testing program and approve CONTRACTOR's water production well design.
2. CONTRACTOR shall be responsible during this period for taking all measures necessary to ensure the integrity of the pilot hole and to protect the drilling site. Not later than 72 hours after final receipt of all sieve analyses and geophysical logs, the COR shall notify CONTRACTOR to undertake reaming of the pilot hole as the first step in construction of a water production well or to abandon the pilot hole in accordance with this Section.

F. Abandonment:

1. If directed by the CO, in writing, the pilot hole shall be abandoned in such a manner to prevent contamination of the aquifers encountered in the hole.
  - a. The abandonment of the pilot borehole shall conform to the requirements of Merced County Code. The OGR and CO, based on results of the sieve analyses and geophysical logs, will determine whether this Work will be conducted. The abandonment design will consist of backfilling with cement grout from total depth to 2 feet below ground surface. Drill cuttings shall be placed from 2 feet below ground surface to grade.

3.2 PRODUCTION WELLS

A. Well Construction:

1. The reverse circulation drilling method shall be used by CONTRACTOR to ream the pilot hole.
2. The final design depths and details, including screen location(s), shall be determined by the CONTRACTOR and approved by the CO after analysis of the results of the pilot hole testing program.
3. Water alone shall be employed as drilling fluid. Should lost circulation or other drilling conditions require the addition of bentonite, lost circulation materials, or other such materials, the addition of these materials shall be made only upon approval of the OGR. CONTRACTOR is cautioned to maintain the minimum viscosity of the drilling fluid that will raise cuttings and adequately condition the walls of the holes. Procedures shall be adopted to ensure the removal of any additives during development.
4. In the event that lost circulation conditions are encountered during the reverse circulation rotary drilling process, immediate remedial action shall be taken by CONTRACTOR to restore circulation of the drilling fluid. Conventional techniques for restoring circulation shall be employed. Cementing, except under extraordinary conditions, shall not be employed below the projected static water level. Only materials acceptable in typical water well drilling shall be used to control loss of circulation. These materials shall consist of wood fiber, nut shells, mica, clays or gels, or other suitable materials and shall be approved by the OGR prior to use.
5. The pilot hole shall be reamed to a diameter allowing a minimum 3-inch annulus between the borehole wall and the well casing, to a depth of 700-feet assuming CONTRACTOR did not elect to install the conductor casing prior to pilot hole construction. The OGR may direct the reaming to a greater or lesser depth based on review of the results of the pilot hole program. A 30-inch-diameter surface conductor casing with grout seal

shall be set in the reamed borehole such that one foot of the casing extends above the ground surface. The casing shall be securely anchored at the ground surface and set to a minimum depth of 50 feet. After the surface casing has been installed, it shall be sealed by filling the annular space between the reamed borehole and the surface casing with cement grout placed in one continuous application from the bottom of the zone to the ground surface.

6. Installation of Well Casing, Screen, Filter Pack, and Seal:

- a. CONTRACTOR shall be responsible for installing the water production well casing, screen, and filter pack such that no damage will result and the intended design criteria are met. If for any reason the installation cannot be made in the correct position or at a depth acceptable to the CO, CONTRACTOR shall construct another well immediately adjacent to the original location and complete this well in accordance with this Section, at no additional cost to the GOVERNMENT. The abandoned hole shall be sealed, as directed by the OGR, in writing, at CONTRACTOR'S expense. If any of the casing or screen should collapse prior to water production well completion, it shall be withdrawn and replaced at CONTRACTOR's expense.
- b. Installation of gravel pack:
  - 1) Prior to placement of the gravel pack, the return line from the mud pit will be sealed off and the drilling fluid shall be thinned with clean water to the satisfaction of the OGR. The gravel pack shall be carefully installed in the annular space to ensure complete filling of the annular space from the bottom of the borehole to a level no more than 20 feet above the top of the upper-most well screen.
  - 2) During the entire gravel packing operation, clean water shall be circulated down the annular space outside of the well screen and out through the perforations in the well screen into the well hole. During gravel pack installation, a swab shall be carefully worked opposite all perforated sections of casing while circulating with clean water. As the gravel pack settles, more shall be added. This operation shall be continued until there is no further measurable settlement of the gravel pack, and the gravel pack has been washed clean.
  - 3) Gravel pack material shall be placed in the bottom of the borehole by a tremie pipe that is gradually withdrawn as the material is placed. Pumping of the gravel pack material through the tremie pipe shall be performed, if required by the OGR. Upon completion of this operation, and after removal of the swab, all rock, sand and foreign materials



shall be removed from the casing by bailing, and the annulus shall be refilled with gravel pack, as necessary.

- c. Sealing-off Strata.
  - 1) CO may require that non-water-bearing zones or water-bearing zones of poor quality below the Corcoran Clay be cased off using blank casing. In such zones, blank casing and an annular seal consisting of hydrated bentonite will be used to seal off the undesirable zones, and shall be installed in accordance with County of Sacramento Code, Title 6, Chapter 6.28.040.A.6.
- d. Installation of upper bentonite seal and formation stabilizer:
  - 1) An approximate 10-foot thick bentonite seal shall be installed in the well annulus to fill the void between the casing and borehole starting at the top of the upper-most filter pack. The bentonite seal shall be installed simultaneously with the reverse circulation of fluid down the annulus, until such time that the annulus has been sealed and circulation can no longer be maintained.
  - 2) A cement grout seal shall be placed from the top of the upper bentonite seal to the land surface to completely fill the annular space between the borehole and the well casing. The grout seal mix shall be cement grout. The seal shall be effective against infiltration of all water.
  - 3) Installation of the grout seal shall be accomplished by pumping through a tremie pipe inserted between the casing and the borehole. The upper cement grout seal shall be placed in one continuous operation from the bottom to the top of the interval to be grouted, forming a continuous seal. CONTRACTOR shall be responsible to maintain an equalization of pressures to the extent necessary to prevent collapse of the well casing.
  - 4) The tremie pipe shall be lowered to within two feet of the bottom of the zone to be grouted. The tremie pipe shall be slowly withdrawn as the annulus fills with grout, but care shall be taken to ensure that the discharge end of the tremie pipe remains submerged a minimum of five feet in the grout at all times while grouting operations are in progress. After the grout has been placed, it shall be allowed to set for a period of at least 24 hours.

B. Method of Water Production Well Construction:

- 1. The pilot hole shall be reamed to a minimum 24-inch-diameter to total depth. The CO may, however, order the reaming to a greater or lesser depth if found advisable after review of the results of the pilot hole

program. CONTRACTOR shall ensure that the final well diameter complies with Merced County Water Well Standards.

2. If the completed water production well depth is less than the depth of the pilot hole, a concrete grout plug shall be placed at the bottom of the reamed borehole in accordance with Paragraph 3.1.F., above.
3. The lengths of the screen and casing to be installed in the borehole shall be as directed by the COR. The preliminary well design is 240 feet of screen from 460 to 700 feet below ground surface, and 463 feet of casing from 460 feet below to 3 feet above ground surface. CO may require that non-water-bearing zones or water-bearing zones of poor quality below 460 feet be cased off using blank casing. In such zones, blank casing and an annular seal consisting of hydrated bentonite will be used to seal of the undesirable zones, and shall be installed in accordance with County of Sacramento Code, Title 6, Chapter 6.28.040.A.6.
  - a. Conductor casing shall be field welded. The ends of each length of surface casing shall be machine-beveled perpendicular to the casing axis to ensure straightness of each assembled section. All welding shall be performed in accordance with the American Welding Society Standards.
  - b. Well casing shall be field assembled by welding adjoining casing ends by the shielded metal electrode arc welding process. The ends of each length of well casing axis shall be machine-beveled perpendicular to the casing axis to ensure the straightness of the assembled section. For field welding, the ends of each joint of well casing shall be clean and free of dirt, oil, scale, and rust. Three complete welding passes shall be made. Each pass shall be smooth and free of blisters, scale, bubbles, cracks, and imperfections that would contribute to a lack of strength of the overall welded joint. The ends of the casing joints shall be sufficiently separated to assure 100 percent penetration of the weld. After welding, each joint shall be watertight. All welding shall be performed in accordance with American Welding Society Standards.
  - c. Screen sections shall be field welded. The ends of each length of screen shall be machine-beveled perpendicular to the screen axis to ensure straightness of each assembled section. One end of each screen section shall be furnished with a factory-welded collar 1/4-inch thick and having a minimum width of 5 inches. Collars shall be of the same physical and chemical properties as the screen and shall be rolled to fit the screen's outside diameter. The inside edge of the collars shall be ground or sufficiently scarfed to remove sharp edges or burrs.

- d. Field welding of the screen sections shall be by lap welding with a continuous 1/4-inch fillet weld. All welding shall be performed in accordance with the American Welding Society Standards.
- e. The screen and casing assembly with centralizers shall be constructed and suspended in the center of the reamed borehole using a casing clamp. The assembly is to be suspended in the borehole to ensure that it is not supported from the bottom. After the casing and screen assembly is properly suspended in the reamed borehole, filter packing operations shall begin.
- f. A 2-inch-diameter combination steel sounding tube and well vent shall be installed to the full depth of the screen interval.
- g. A 3-inch-diameter gravel feed tube shall be installed to a depth 5 feet below the bottom of the upper bentonite well seal and into the gravel pack. If well construction requires multiple well screens separated by blank casing, CONTRACTOR shall install a 3-inch-diameter gravel feed tube into each gravel pack zone.

C. Development by Air-lifting, Swabbing and/or High Velocity Jetting:

- 1. The first stage of development shall occur after the placement of the filter pack to a level selected by the OGR. Development shall be by air-lifting or high velocity water jetting in conjunction with swabbing. CONTRACTOR will submit details on how he intends to perform this operation including equipment specifications. The development will begin at the bottom of the well and proceed upward. CONTRACTOR shall add approximately 300 pounds of sodium acid pyrophosphate or OGR-approved equivalent material to aid in dispersion of the drilling fluid. The dispersing agent shall be added to the well as directed by the OGR.
- 2. CONTRACTOR shall discharge development water on-site into the Volta wasteway. CONTRACTOR shall take measures to avoid erosion of Site soils or sediment in the wasteway or along its bank.

D. Development by Pumping and Surging:

- 1. CONTRACTOR shall furnish, install, operate, and remove an electric pump suitable for the intended purpose to further develop the well. CONTRACTOR shall furnish, maintain, operate, and remove a power source for providing electricity to operate the pump during development. The pump and prime mover shall be operational between 1,000 and 2,000 gallons per minute (gpm) against a total head of 300 feet at an intake setting of 450 feet. The prime mover shall be a variable-speed type. CONTRACTOR shall furnish and install a pump controller, and discharge piping for the pumping unit of sufficient size and length to conduct water to a point designated by the OGR. CONTRACTOR shall also furnish a

valve in close proximity to the orifice discharge of a type that is easily adjustable and sensitive (e.g., butterfly). CONTRACTOR shall also furnish, install, and operate acceptable orifices, meters, or other COR-approved devices, which will accurately measure and record the flow rate. Two sounding tubes shall be installed to a depth designated by the OGR to allow water levels to be easily measured by CONTRACTOR.

2. The initial pumping rate shall be restricted and as the water clears shall be gradually increased until the maximum rate is reached. The maximum rate will be determined by the OGR based on the production well's drawdown and discharge characteristics. At proper intervals the pump shall be stopped and the water in the pump column shall be allowed to flow back (surge) through the pump bowls and the screen area.
3. CONTRACTOR shall repeat the cycle of pumping and surging until, in the opinion of the OGR, the following conditions have been properly met:
  - a. Sand production shall be less than 15 parts per million (ppm) within 20 minutes after commencement of pumping at the production rate selected by the OGR. Average sand production shall not exceed one ppm for a 2-hour cycle at that production rate. Sand production shall be measured by a Rossum Sand Tester, which shall be properly installed by CONTRACTOR.
  - b. The discharged water is clear of sand, silt, and mud.
  - c. There is no increase in specific capacity during at least 24 hours of continuous pumping and surging.
4. Following well development, CONTRACTOR shall provide water to fill sample containers provided by OGR. Air-lift or submersible pump is acceptable to obtain water samples.

E. Plumbness and Alignment:

1. CONTRACTOR shall perform a test for plumbness and alignment of the well casing prior to acceptance of the water production well by the CO. The test shall be performed by lowering a plummet or cage from the surface to the depth at which the cone reducer is installed and measuring deviations from the vertical axis at 10-foot depth intervals. The plummet or cage shall be at least one foot long and have a minimum outside diameter 1/2-inch smaller than the inside diameter of the casing. The test may be performed by CONTRACTOR at any time after the water production well casing is permanently set. The results of the test shall be analyzed by CONTRACTOR, and a plot of deviations versus depth in east-west and north-south orientations prepared and presented to the COR to document compliance with these requirements. In order to meet the requirement for plumbness and alignment, it is expected that CONTRACTOR shall exert careful control on drilling rates and bit

weights and shall perform alignment tests at his own expense during the construction operations. Should the water production well fail to meet the requirements for plumbness and alignment, it shall be corrected by CONTRACTOR, or a new acceptable well drilled, at no additional cost to the GOVERNMENT.

2. To meet the test for alignment, the axis of the water production well casing shall not deviate from the vertical in excess of two-thirds the inside diameter of the casing per 100 feet of depth and the deviation shall be reasonably consistent regarding direction.

F. Water Production Well Testing:

1. Following water production well completion, the water production well shall be tested to select the design production rate and to determine the drawdown at that rate. CONTRACTOR shall utilize the pumping equipment and measuring equipment described in Paragraph 3.2.D.1., above, to perform the production testing. GOVERNMENT will be responsible for energy dissipation during the test so as to not cause erosion of earthen structures at the discharge point. A test procedure shall be furnished to CONTRACTOR by the COR prior to beginning the test.
2. Prior to start of the test, CONTRACTOR shall pull the pump equipment and install a check valve on top of the pump to prevent backflow of water once the test has been stopped. CONTRACTOR shall furnish, maintain, operate, and remove a power source for providing electricity to operate the pump throughout the duration of the test
3. CONTRACTOR shall be responsible for making all measurements of flow and water level during the test at the intervals selected by the OGR.
4. A step-drawdown test will require continuous pumping at 1,000, 1,500, and 2,000 gpm for two hours at each step.
5. The pump test will require continuous pumping at a rate selected by OGR for a period of 120 hours (5 days), or as directed by the OGR.
6. CONTRACTOR shall also collect measurements for a 24-hour period following completion of the production test to measure recovering water levels. The recovery test may be extended or shortened by OGR based on field measurements.
7. CONTRACTOR shall, upon completion of testing, deliver a copy of the development and test records to the COR.
8. At the completion of the production/recovery testing, all sand, silt, and other materials shall be removed from the well and spread on-site.

G. Disposal of Waste Water:

1. CONTRACTOR shall be allowed to discharge waste water generated from cleaning equipment on-site into the Volta Wasteway.

H. Disposal of Drilling Mud:

1. CONTRACTOR shall be allowed to discharge drilling mud on-site in an area approved by GOVERNMENT and identified by OGR.

I. Close-Out Procedures:

1. Upon completion of water production well testing and removal of the test pump, CONTRACTOR shall run a color TV survey of the entire well depth.
  - a. The TV equipment introduced into the water production well shall be thoroughly washed and disinfected in a manner approved by the OGR, prior to inserting into the well.
  - b. CONTRACTOR shall make available two copies of the video tape to the COR.
  - c. If the video tape indicates material in the bottom of the well, CONTRACTOR shall remove it.
2. CONTRACTOR shall cap the production wells with a welded steel plate and vent cap following completion of production testing and upon approval by CO.
3. CONTRACTOR shall remove all debris, excess materials, mud pits and ensure final grading and restore the Site to original conditions.
4. CONTRACTOR shall demobilize all equipment and materials. All refuse and any other material foreign to the Site shall be removed by CONTRACTOR.

### 3.3 MONITORING WELL

A. Well Construction:

1. The mud rotary drilling method shall be used by CONTRACTOR to drill the monitoring well borings.
2. The preliminary screen depths for the monitoring wells are 50-80 feet, 200-240 feet, and 460-480 feet. The final design depths and details, including screen location, shall be determined by the CO after analysis of the results of the pilot hole testing program.

3. Installation of Well Casing, Screen and Filter Pack:
  - a. CONTRACTOR shall be responsible for installing the monitoring well casing, screen, and filter pack such that no damage will result and the intended design criteria are met. If for any reason the installation cannot be made in the correct position or at a depth acceptable to the CO, CONTRACTOR shall construct another well immediately adjacent to the original location and complete this well in accordance with this Section, at no additional cost to the GOVERNMENT. The abandoned hole shall be sealed, as directed by the COR, in writing, at CONTRACTOR's expense. If any of the casing or screen should collapse prior to monitoring well completion, it shall be withdrawn and replaced at CONTRACTOR's expense.
  - b. Installation of gravel pack:
    - 1) Prior to placement of the gravel pack, the return line from the mud pit will be sealed off and the drilling fluid shall be thinned with clean water to the satisfaction of the OGR. Gravel pack shall be installed in the annular space as shown on Drawing W1. The gravel pack shall be carefully installed to ensure complete filling of the annular space from the bottom of the borehole to a level no more than 10 feet above the top of the well screen.
    - 2) Gravel pack material shall be placed in the bottom of the borehole by a tremie pipe that is gradually withdrawn as the material is placed. Pumping of the gravel pack material through the tremie pipe shall be performed, if required by the OGR. Upon completion of this operation, and after removal of the swab, all rock, sand and foreign materials shall be removed from the casing by bailing, and the annulus shall be refilled with gravel pack, as necessary.
  - c. Installation of bentonite seal. A bentonite seal shall be installed in the well annulus to fill the void between the casing and borehole from the top of the filter pack to approximately 10 feet above.
  - d. Installation of cement grout seal:
    - 1) The cement grout seal shall be placed from the top of the bentonite seal to the land surface to completely fill the annular space between the borehole and the well casing. The grout seal mix shall be cement grout. The seal shall be effective against infiltration of water.
    - 2) Installation of the grout seal shall be accomplished by pumping through a tremie pipe inserted between the casing and the borehole. The upper cement grout seal shall be placed in one continuous operation from the bottom to the top of the interval to be grouted, forming a continuous seal. CONTRACTOR shall be responsible to maintain an

equalization of pressures to the extent necessary to prevent collapse of the well casing.

- 3) The tremie pipe shall be lowered to within two feet of the bottom of the zone to be grouted. The tremie pipe shall be slowly withdrawn as the annulus fills with grout, but care shall be taken to ensure that the discharge end of the tremie pipe remains submerged a minimum of five feet in the grout at all times while grouting operations are in progress.
- 4) After the grout has been placed, it shall be allowed to set for a period of at least 24 hours.

**B. Method of Monitoring Well Construction:**

1. The borehole shall be drilled using a nominal 9-inch-diameter bit to total depth.
2. The lengths of the screen and casing to be installed in the borehole shall be as directed by the CO.
  - a. Well casing shall be field assembled using threaded casing.
  - b. Screen sections shall be field assembled using threaded screen sections with a threaded end cap.
  - c. The screen and casing assembly with centralizers shall be constructed and suspended in the center of the borehole using a casing clamp. The assembly is to be suspended in the borehole to ensure that it is not supported from the bottom. After the casing and screen assembly is properly suspended in the borehole, filter packing operations shall begin.
3. The drilling fluid properties shall be approved by the OGR prior to introduction of the filter pack. Before the filter pack operations begin, CONTRACTOR shall make adequate preparations to ensure that circulation of clear water can be maintained on a continuous basis throughout the operation.
4. Filter pack material shall be placed in the bottom of the borehole by a tremie pipe, which will be gradually withdrawn as the material is placed. Pumping of the filter pack material through the tremie pipe shall be performed, if required by the OGR.

**C. Development by Air-lift, Swabbing and/or High Velocity Jetting:**

1. CONTRACTOR shall develop each monitoring well following procedures described in Section 3.2.D, as applicable. CONTRACTOR shall continue development until, in the opinion of the OGR, the discharged water on-site into the Volta Wasteway. CONTRACTOR shall discharge water on-site



into the Volta Wasteway. CONTRACTOR shall take measures to avoid erosion of Site soils or sediment in the wasteway or along its bank.

2. Following well development, CONTRACTOR shall provide water to fill sample containers provided by OGR. Air-lift or submersible pump is acceptable to obtain water samples.

D. Well Completion:

1. CONTRACTOR shall complete the well using a lockable, 5-foot long steel protective casing set in a 5-foot by 5-foot by 0.5-foot thick concrete pad. The concrete pad shall be centered around the monitoring well. The protective casing shall be set two feet below ground surface.

E. Close-Out Procedures:

1. CONTRACTOR shall demobilize all equipment, remove excess materials and restore the Site to the satisfaction of the CO.

END OF SECTION